

**POLICE            ALLOCATION            MANUAL**

Determination of the Number and Allocation of  
Personnel for  
Patrol Services for State Police Departments

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## CHAPTER 1: Introduction

### Purpose of the Manual

The Police Allocation Manual (PAM) is designed to be used by state police agencies, or divisions within those agencies, whose mission includes the delivery of police traffic services. The Manual is designed to help such agencies address two key resource allocation questions:

1. What is the total number of officers (i.e., troopers, field supervisors, and staff and command personnel) that are required to provide an acceptable level of service? and
2. How should a specified total number of officers be allocated by geographic regions or time periods to maximize agency productivity?

This version of the Manual is derived from earlier editions that were based on a review of procedures currently used by state, provincial and county agencies throughout the United States and Canada. The framework and rationale presented in the Manual are the result of a distillation process that identified the "best" procedures, and then modified and blended those procedures into a comprehensive model for determining appropriate staffing levels and deployment patterns.

It is anticipated that the Manual will provide both immediate and long-range benefits. The procedures in PAM will provide agencies with a logical and explicit format in which to frame requests for additional personnel and/or staff allocation. In addition, it is anticipated that the Manual will serve as a catalyst for stimulating further discussion and research in the area of staffing and allocation for law enforcement agencies.

### How To Use the Manual

This "Special Version" of the Police Allocation Manual consists of four chapters and two appendixes. Chapter 1 provides a brief introduction to the purposes and uses of the Manual. Chapter 2 describes the PAM staffing and allocation model. Chapter 3 contains eight worksheets, each with instructions, that provide a step-by-step process for determining staffing levels. Chapter 4 contains one worksheet for determining staff allocation

over several geographic areas or time periods. Appendixes A and B contain worksheets that can be used as alternatives or supplements to the procedures presented in sections 5.2 and 5.3 in Chapter 3.

Additional information about the PAM procedures can also be found in the companion document, Police Allocation Manual User's Guide. The Guide presents implementation, data definitions, and data collection strategies used by the field test agencies plus additional reference materials that were contained in earlier versions of the Manual. Also included in the Guide is a summary of key input values and numerical results obtained by the six agencies that field tested the Manual. The appendix materials in the Guide identify the input data required to use the PAM model (Appendix A), present a glossary of key terms and a list of notation used (Appendix B), include a detailed example showing all nine worksheets in completed form (Appendix C), and illustrate the derivation of all formulas used in the model (Appendix D).

For the first-time user of the Manual, the following procedure is recommended:

1. Read Chapter 2 - Chapter 2 can be used to gain an initial understanding of the overall logic of the model and its major components. (The reader may also want to refer to the material in Appendix D in the Guide.) It is not imperative for the user to understand every detail at first reading. The primary objective of Chapter 2 is to provide readers with sufficient information to assess how the model can best be used to assist their agency.

2. Review Appendix A in the User's Guide - Appendix A provides an overview of the types of data that are required to use the PAM model.

3. Review Chapters 3 and 4 - Chapters 3 and 4 contain all the worksheets and instructions for the PAM model. Appendixes B and C in the Guide can be used as references as needed. The purpose of this step is to enhance understanding of the model, to resolve questions about the procedures that are used, and to help the user assess the effort required to use the model.

4. Determine the Data Collection Effort - After reading chapters 2, 3, and 4 (and referring to appendixes A, B, C, and D in the Guide as needed), the user should estimate the data collection effort that will be required to use the model. The following steps are recommended for this assessment:

- o Review the sections in the Guide entitled "General Implementation Strategies" (Section 2) and "Recommended Data Collection and Implementation Procedure" (Section 4).
- o Review the worksheets in chapters 3 and 4 to identify which model options will be used. (Section 3 in the Guide may also be useful for this step.)
- o Compile a list of the input data requirements for the agency. This list will include all the data items in Worksheet 1 plus additional data items from worksheets 2 - 9 depending on the particular options selected. The user may find it more convenient to use Appendix A in the Guide to compile this list.
- o For each data item on the list, determine its availability, its accessibility, and the effort that will be required to obtain it. It is important to recognize that no agency is likely to have all the data required; it is probable that every agency will have to estimate some of the data items, at least initially. (Section 3 in the Guide provides specific guidelines and recommendations for collecting a number of key input data items.)

5. Assess the Benefits of the Model to the Agency - Before proceeding further, the user should weigh the benefits to be gained from using the model versus the data collection effort that will be required. This tradeoff can be used to help decide whether to use the model or not.

6. Collect the Required Data - If a decision is made to use the model, initial activities should focus on data collection. The actual time required to collect the data will vary considerably by agency and will depend on the size of the agency, the degree of automation within the records section, and the scope of existing records. Initial data collection efforts may require time that will not be necessary for later uses of the model because some input data items are not likely to change (e.g., the number of roadway miles, the size of the patrol areas, etc.).

7. Complete the Worksheets - Once the input data items have been collected, the nine worksheets in chapters 3 and 4 can be used to determine the staffing and allocation levels required for each patrol area. Once the data are available, actual completion of the worksheets themselves will require relatively little time (i.e., only a few hours) compared to the days or weeks that may be required to collect the data.

8. Review and Adjust the Results - After the model has been used to determine staffing and allocation levels, the results should be carefully reviewed. The purpose of this review is to:

- o explicitly identify the rationale for each model option that is used,
- o explicitly identify the rationale for each performance objective value that is used,
- o verify that the agency data used is both comprehensive (e.g., that all patrol workload is accounted for) and consistent with model data definitions, and
- o identify and understand differences between current staffing levels and those specified by the model.

#### The Role of Resource Allocation Models

It is important for PAM users to remember that the Manual is based on a "model" of staffing and deployment. All models are limited by the assumptions on which they are built and by the data that are used. (See Chapter 2 for additional discussion concerning the limitations of the PAM model.) The user must guard against the temptation to believe that the model provides "the answer." All models, including the one described in the Manual, use a variety of assumptions about the "real" world to assemble data into rational patterns that can be used by decision-makers. (Police administrators do not suffer from a lack of data, but rather from a scarcity of tools for effectively using that data.) The decision-maker, in turn, must weigh the merits of the recommendations of the model against other factors (e.g., political, economic, operational, etc.) in arriving at a final course of action. Perhaps John Schuiteman said it best when he wrote:

"Adequate police protection, like beauty, lies in the eye of the beholder. The optimal or appropriate ratio of troopers to population, traffic volumes, reported crimes or accidents, etc., is not a matter of mathematics or statistics. It is a matter of human judgment and community resources."

"Allocating State Troopers:  
The Virginia Experience," The  
Police Chief, July 1985.

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## CHAPTER 2: Overview of the Police Allocation Manual Methodology

### Time-Based Model

The procedures used in the PAM model to determine the total staff requirements for the delivery of police patrol services are based on an analysis of patrol workload requirements, performance objectives, and personnel policies, all measured in time. All trooper time, both on and off-duty, is divided into two categories: patrol and non-patrol. Non-patrol time, determined largely by the personnel policies of the agency, is reflected in the "shift relief factor" determined in Worksheet 8 of the Manual. All patrol time is divided into four time components:

1. Reactive time (calls-for-service),
2. Proactive (self-initiated) time,
3. Proactive (uncommitted patrol) time, and
4. Administrative time.

#### Reactive Time

Reactive time refers to patrol time spent on activities that can be described as service-on-demand. These are usually calls for service (CFS) that are assigned by radio dispatch. For some agencies, the most important CFS activities are requests for police assistance at traffic accidents. Since most agencies also provide services beyond traffic-related activities, the PAM model classifies all CFS as either "accidents" or "other CFS." The total time spent answering CFS is referred to as "obligated time."

#### Proactive (Self-Initiated) Time

Proactive (self-initiated) time refers to patrol time spent on non-CFS activities. In the PAM model, self-initiated activities include the issuance of citations and warnings for driving violations, assisting motorists, providing traffic direction and control, and conducting field interrogations.

### Proactive (Uncommitted Patrol) Time

Proactive (uncommitted patrol) time refers to the time spent patrolling the roadway system in the jurisdiction (i.e., time not spent on reactive, self-initiated, or administrative activities). Uncommitted patrol provides two benefits: "visibility" for the general deterrence of traffic and criminal violators, and "availability" for self-initiated activities and for the timely response to CFS. Uncommitted patrol time includes time spent on both moving and stationary patrol.

### Administrative Time

Administrative time refers to patrol activities that do not fall into the reactive, self-initiated, or uncommitted patrol time categories. Typical administrative activities include on-duty court time, personal time (e.g., for meals), patrol car maintenance, training, and agency administrative duties. On-duty time spent on non-patrol activities such as extended training or special assignments are accounted for in the calculation of the shift relief factor for the agency.

### Autonomous Patrol Areas

The PAM procedures are designed to determine total staffing requirements for "autonomous patrol areas"; that is, geographic areas that exhibit the following characteristics:

- o virtually all of the CFS that originate in the area are handled by troopers assigned to the area (or conversely, few CFS in the area are handled by troopers assigned to other areas);
- o troopers assigned to the area are rarely assigned to CFS outside of the area; and
- o although troopers may be assigned to specific geographic subdivisions within the area for patrol, a trooper may be dispatched, if required, to a CFS anywhere within the area.

In some agencies, each district or zone operates as an autonomous patrol area (APA). In others, with larger geographic areas, one district may consist of several APAs. In some cases, the entire county may serve as a single APA.

### Total Staff Requirements

To determine the total staff requirement for an agency, the PAM model is used in the following way:

1. The entire jurisdiction is used as single autonomous patrol area (APA) or is subdivided into a number of autonomous patrol areas (APAs). The APAs should cover the entire jurisdiction and should not overlap one another.
2. The PAM procedures are used to determine the total staffing requirement for each APA.
3. The staffing requirement for the entire jurisdiction is obtained by adding the staffing numbers for all the APAs. (The resulting total may need to be supplemented with additional personnel assigned to the central or regional headquarters of the agency.)

The PAM model uses the following steps to determine the total staffing requirement for each APA:

1. Determine the average daily on-duty staff requirement (i.e., the number of troopers required to meet the administrative, reactive, self-initiated, and uncommitted patrol requirements). The resulting number of troopers is then adjusted for the use of two-officer patrol units, specialized units, and, if applicable, minimum staffing requirements.
2. Determine the average number of on-duty field supervisors required to support the average daily on-duty trooper requirement. The number of troopers is then adjusted to account for patrol workload performed by field supervisors.
3. Determine the total staff requirement (i.e., the total number of personnel needed, both on and off-duty, to support the required on-duty patrol presence) for the APA. The total staff requirement will include troopers, field supervisors, and staff and command personnel.

### Average Daily On-Duty Trooper Requirement

The PAM model determines the average number of on-duty troopers that will be required each day (i.e., within each

24-hour period) based on the following formula (see Appendix D in the Guide for a derivation of this formula):

$$N = \frac{N_r + N_p}{1 - \frac{m_a}{60} - \frac{m_s}{60}}$$

where:

- N** - the average number of on-duty troopers required per day (i.e., per 24-hour period),
- N<sub>r</sub>** - the average number of on-duty troopers required per day to service all CFS and accidents in the APA,
- N<sub>p</sub>** - the average number of on-duty troopers required per day to provide the specified level of uncommitted patrol in the APA,
- 1** - a constant,
- m<sub>a</sub>** - the average number of minutes per hour spent on administrative activities by each on-duty trooper,
- m<sub>s</sub>** - the average number of minutes per hour spent on self-initiated activities by each on-duty trooper, and
- 60** - a constant.

Much of the effort required to use the PAM model is spent determining appropriate values for **N<sub>r</sub>**, **N<sub>p</sub>**, **m<sub>s</sub>**, and **m<sub>a</sub>** based on the workload level, operational policies, and roadway and traffic characteristics of the agency and patrol area. The basis for deriving each of these values is outlined below.

Number of troopers for reactive time workload (N<sub>r</sub>). The average number of troopers required per day to provide service for all accidents and other CFS in the patrol area is based on the average total obligated time per day required for all accidents and other CFS, and the shift length used by the agency.

Number of troopers for uncommitted patrol time (N<sub>p</sub>). The average number of troopers required per day to provide uncommitted patrol is based on:

- o the number of troopers required to provide an adequate level of uncommitted patrol visibility as measured by the "patrol interval" (i.e., the average time between trips past any given point on the roadway); and
- o the number of troopers required to insure a timely response to obligated time activities.

The number of troopers required for visibility is based on the miles of roadway to be patrolled, the hours of coverage per week, the average uncommitted patrol speed, the shift length, and the desired patrol interval by roadway type. As an example, a patrol interval of eight hours indicates that a trooper will be observed on uncommitted patrol on a given roadway segment about once every eight hours or three times per day.

Two criteria are available in the PAM model for determining the number of troopers required for a timely response to CFS. The number can be determined based on either:

- o the percent of obligated time activities for which a trooper is immediately "available" (i.e., a trooper not currently involved in a CFS, self-initiated, or administrative activity), or
- o the average travel time to each obligated time activity.

The number of troopers required for immediate response is based on the average number of troopers required per shift for reactive time activities and the immediate response percent set by the agency. Travel time values are based on the size of the patrol area (and/or roadway miles if line patrol is used), the hours of coverage per week, the average response speed, the shift length, and the average travel time objective set by the agency.

Self-initiated time per hour per trooper ( $m_s$ ). The PAM model does not attempt to directly determine the total number of troopers that are necessary for all self-initiated activities. To produce such a value would require an accurate measure of the total self-initiated workload for the agency (i.e., the total time that an agency should spend on these activities within the patrol area). To avoid the difficulties associated with determining this value, the PAM model focuses on the number of minutes per hour spent on self-initiated activities by each trooper ( $m_s$ ). The PAM model allows the user either to specify a value for  $m_s$  or to derive a value based on self-initiated data for the agency from previous years.

Administrative time per hour per trooper ( $m_a$ ). Paralleling the rationale given above for determining  $m_s$ , the PAM model does

not attempt to determine the total administrative workload of the patrol force, but rather focuses on the amount of administrative time required per hour per trooper ( $m_a$ ). The PAM model permits the user either to specify a value for  $m_a$  or to estimate it based on agency experience.

#### Adjustments to the Average Daily Number of On-Duty Troopers

The initial value for the average number of on-duty troopers required per day is examined to determine whether additional or fewer troopers are needed because of:

- o the use of two-trooper patrol units,
- o patrol provided by troopers assigned to specialized units (e.g., hazardous materials or accident investigations), and
- o minimum staffing levels.

#### Average Daily Number of On-Duty Field Supervisors

The average number of on-duty troopers required per day serves as the basis for calculating the number of on-duty field supervisors required. Two factors are used to determine the final number of on-duty troopers and supervisors:

- (1) the average number of troopers supervised by each field supervisor (set by agency policy), and
- (2) the fraction of each field supervisor's time spent on patrol (i.e., non-supervisory) activities.

#### Total Staff Requirements

Worksheet 8 of the PAM model is used to determine the total number of personnel, both on- and off-duty, required to support the average number of on-duty troopers and field supervisors required per day. The total number of personnel consists of troopers, field supervisors, and staff and command personnel. The total number of troopers and field supervisors is determined using the shift relief factor for the agency. This factor indicates the average number of officers required to staff one shift position every day, and is based on the shift length, the average work week, and the average number of on-duty patrol hours expected from each officer per year. The number of staff and command personnel required is specified as a policy decision by the user.

### Total Staff Allocation

The final worksheet in the Manual (Worksheet 9 in Chapter 4) is used to determine staff allocation over several geographic areas based on the PAM staffing estimates for each APA and the total number of staff personnel available for deployment. Although the discussion in this section and Chapter 4 refers only to the allocation of staff over several APAs (i.e., allocation over geographic areas), the logic of the procedure can be applied equally well for allocation over time periods (e.g., staff allocation over shifts or days of the week). To use Worksheet 9 for allocation over different time periods, however, requires that PAM staffing estimates be obtained for each time period of interest.

Worksheet 9 can be used to determine two kinds of allocations.

#### Unconstrained Allocation

Unconstrained allocation refers to a redistribution of all available staff among several APAs according to the percentage of staff in each APA based on staff estimates from the PAM model. Such an allocation is called "unconstrained" because it is possible that a reallocation of the total staff may produce a deployment in which some APAs gain staff and other APAs lose staff.

#### Constrained Allocation

Constrained allocation refers to a reallocation of staff under the following limitations:

- o if the total staff is to be increased, no APA will lose staff because of the reallocation, or
- o if the total staff is to be decreased, no APA will gain staff because of the reallocation.

The process for determining the allocation under these limitations consists of the following steps:

1. The results of the unconstrained allocation are used to characterize each APA as either overstaffed or understaffed.
- 2a. If the total staff is to be increased, the additional staff (i.e., the difference between the current total staff and the final total staff) are allocated, based on the PAM staffing estimates for each APA, only to those APAs that are currently understaffed; (Staffing levels for overstaffed APAs remain unchanged.) or

- 2b. If the total staff is to be decreased, the staff reduction (i.e., the difference between the current total staff and the final total staff) is allocated, based on the PAM staffing estimates for each APA, only to those APAs that are currently overstaffed. (Staffing levels for understaffed APAs remain unchanged.)

It is possible under the limitations of constrained allocation that, even after reallocation, some APAs may still be over or understaffed.

### Limitations of the PAM Model

The PAM model, as presented in this document, should be viewed as a generic procedure that must be adapted to fit the mission, physical environment, roadway system, and operational idiosyncrasies of each agency. State police departments in the United States exhibit a wide range of missions: from full-service police agencies to departments with limited responsibilities. The varieties of agency missions, in turn, exist within a wide range of environmental and roadway settings.

In addition, there are a number of issues which, although addressed in a general sense in the PAM model, represent relationships and circumstances for which additional research and operational experience are needed. Some of these areas include:

- o the impact of county and municipal law enforcement agencies upon the mission and resource requirements of state agencies;
- o the relationship between the amount of self-initiated work and various roadway and traffic characteristics;
- o the determination of travel time for large non-urban areas with sparse roadway systems; and
- o the determination of staffing requirements for high-volume, high-density, urban interstate and expressway systems.

CHAPTER 3: PAM Instructions and Worksheets for  
Determining Total Staff Requirements

Introduction

This chapter provides a systematic format and process for determining the total staff requirements for state police departments providing patrol services in autonomous patrol areas. The process is presented in a series of eight worksheets entitled:

- Worksheet 1: Operations, Workload, and Roadway Data
- Worksheet 2: Administrative Time
- Worksheet 3: Reactive Time
- Worksheet 4: Proactive Time - Self-initiated
- Worksheet 5: Proactive Time - Uncommitted Patrol
- Worksheet 6: Average Daily Number of On-Duty Troopers
- Worksheet 7: Special Assignments and Field Supervision
- Worksheet 8: Total Staff Requirements

Worksheet Format

The same format for each data entry and calculation step is used in all eight worksheets. Each worksheet is divided into a number of sections. The beginning and end of each section are identified with a double line. Each section, in turn, consists of a series of individual steps. For each step, a numeric value is obtained and recorded in a box on the right-hand side of the worksheet. Each box is labeled with a numeric identifier to facilitate reference to values that are used in later steps, sections, or worksheets. The numeric value that is recorded for each step is obtained in one of four ways:

- o data collection,
- o policy decision,

- o referenced from an earlier step, or
- o calculated using the method or formula given in the worksheet based on numeric quantities from previous steps.

Two methods are used to highlight important results:

1. The box is drawn with double lines, and/or
2. A letter notation, shown in parentheses to the right of the box, is used to identify the result.

Preceding each worksheet is a brief description of its purpose followed by instructions for individual steps and the anticipated source of required data items; that is: data collection (D), policy decision or current agency practice (P), referenced value (R), or calculation (C).

For some procedures, more than one method is available for obtaining a particular data item. When two or more options are presented, they are separated by a pair of horizontal lines with the word "OR" between them.

#### Terminology, Notation, and Key Assumptions

Appendix B in the Guide presents definitions for key terms that are used in the PAM instructions and worksheets. The appendix also lists and identifies all abbreviations and notations that are used in the worksheet formulas.

Within the Manual, the term "patrol" refers to the activities associated with all four time categories used in the PAM model (i.e., reactive, self-initiated, administrative, and uncommitted). "Non-patrol" refers either to off-duty time or to on-duty time spent on temporary special assignments that do not include activities in any of the four time categories. (A more detailed discussion of non-patrol time is presented in the instructions for Worksheet 1.) The term "uncommitted patrol" refers to one of the four time categories and represents patrol time spent in the field while not engaged in reactive, self-initiated, or administrative activities. This definition of patrol is sometimes referred to as "preventive patrol" or "uncommitted time." The total uncommitted patrol time per hour equals the time left over when the average number of minutes per hour spent on reactive, self-initiated, and administrative activities is subtracted from 60 minutes. The appropriate meaning of "patrol" in the Manual is indicated by the context in which it is used.

The PAM model is based on a number of assumptions that are identified in the instructions preceding each worksheet. Two key assumptions that should be kept in mind are:

1. The total staff requirement determined with the worksheets is only applicable to autonomous patrol areas (APA). If a district or zone consists of more than one APA, the total staffing requirement for the district or zone is obtained by determining the staffing requirement for each APA and adding the results together.
2. The procedures used in worksheets 1-5 and Section 6.1 of Worksheet 6 assume the use of only one trooper for each patrol unit. As a result, the phrases "number of troopers" and "number of patrol units" are used interchangeably. An adjustment for the use of two-trooper patrol units is presented in Section 6.2 in Worksheet 6.

Instructions for Worksheet 1: Operations, Workload, and Roadway Data

Worksheet 1 is used to identify most of the data items that will be used in worksheets 2 - 8. Worksheet 1 is not a complete list of all the data items that may be needed since several of the worksheets permit the use of optional procedures, each requiring a slightly different set of data items. (A complete list of all input data items is presented in Appendix A in the Guide.)

Some procedures in the worksheets use the number of roadway miles in the APA as part of the calculation process. The worksheets in this version of the Manual are designed to accommodate up to three categories or types of roadways. (More than three can be easily accommodated if necessary). Each PAM user is free to determine how many types will be used and what the definition of each category will be. How many types to use and what the definition of each should be is related to the variety and extent of roadways in an APA and the nature of the data collection system used by the agency. Possible roadway categories that can be used are controlled-access, U.S. highway, expressway, freeway, state highway, primary roadway, secondary roadway, rural roadway, municipal, and residential streets. Definitions for some roadway categories are provided in Appendix B in the Guide.

Regardless of how many roadway types and what definitions are used, all roadways in the APA regularly patrolled by the agency must be included in one of the roadway types.

Instructions for Individual Steps

1.1 Name of the autonomous patrol area (usually a district, zone, or county) (D).

1.2 Operations Data for the APA

1.2.1 Shift length is the number of hours each trooper is on duty for one tour or watch or shift (P). If shift length varies by trooper or assignment, an average value should be used.

1.2.2 The average number of on-duty hours on patrol per year per trooper refers to the actual number of hours that a trooper appears for regular patrol duty each year (D). This number should include both regularly scheduled on-duty time and paid overtime. (See discussion below about "non-patrol" time.) The average number of actual on-duty hours spent on patrol may be determined in a

number of ways. The agency may have a system that keeps track of the number of on-duty patrol hours for each trooper. If this system is used, the average number of hours is obtained by adding all the on-duty patrol hours and dividing by the number of troopers. In some agencies, it may be easier to determine the average on-duty hours per year on patrol per trooper by assuming that each trooper works one shift on patrol every day and then subtracting the average number of non-patrol hours, both on and off-duty, per year per trooper.

"Non-patrol" time consists of:

- (1) regular days off - unpaid time off. The number of regularly-scheduled days off is determined by the shift length and the average work week (e.g., an 8-hour shift length and a 40-hour work week produces an average of 2 days off per week).
- (2) benefit days off - paid days off. Benefit days off usually include vacation leave, sick leave, holiday leave, compensatory time off, and a variety of other kinds of days off that vary by agency and region.
- (3) temporary special assignments - on-duty assignments that remove an officer from patrol operations (e.g., attendance at a training course, assignment to duty at the county fair, limited duty status, etc.). It is recommended that only assignments that last one or more shifts at a time be included in this category. Activities that require less than one shift (e.g., roll-call training and desk duty for one or two hours) should be included as administrative time when estimating  $m_a$  in Worksheet 2.

1.2.2.1 Average work week (P).

The average number of hours an officer is paid for each week. Most agencies use 40 hours per week, although it is not uncommon to find values that are slightly above or below this.

1.2.2.2 Average number of benefit hours off per year per officer (P).

The average number of paid off-duty hours an officer uses per year for vacation, holidays, illness, compensatory time off, etc. It is important to note that this value is benefit time taken which may be less than benefit time earned per year. Since this value reflects the specific benefit time-off policies and experience of an agency, it can only be estimated by collecting data on the benefit time off history of the agency.

- 1.2.2.3 Average number of on-duty hours spent on temporary (non-patrol) special assignments per year per officer.

Paid on-duty time that is not spent on regular patrol operations.

- 1.2.3 Average number of troopers to be supervised by one field supervisor (P).

- 1.2.4 Percent of field supervisor on-duty time spent on patrol activities (D).

"Patrol activity" refers to any activity that would be performed by a trooper if the field supervisor was not present. Alternatively, patrol activities for field supervisors can be thought of as all non-supervisory activities. The percentage is a number between 0 and 100. A value of 0 indicates that each field supervisor spends no (zero) time on patrol activities. A value of 50 indicates that each field supervisor spends an average of 50% of his/her time on patrol activities.

- 1.2.5 Patrol operations - roadway category 1

- 1.2.5.1 Name or type of roadway used for category 1.

- 1.2.5.2 Coverage per week (P)(D).

The number of hours that category 1 roadways in the patrol area are covered per week. A roadway is considered "covered" during a shift if at least one trooper has patrol responsibility for the roadway. Note that a "covered" roadway does not imply that the patrol level is adequate; merely that at least one unit has patrol responsibility for it whether it can provide adequate coverage or not.

Coverage is expressed in hours per week (i.e., a number between 0 hours (no coverage) and 168 hours (coverage 24 hours per day, seven days a week). Coverage in shifts per week can be easily converted to hours; e.g.,

<u>Patrol Coverage, Number of 8-Hours Shifts per Week</u>	<u>Patrol Coverage, Number of Hours Per Week</u>
21	168
14	112
5	40

If coverage varies by roadway location, determine an overall average level of coverage based on the following formula (assuming three coverage levels):

$$\text{Average Coverage (hrs/wk)} = \frac{H_1 \times M_1 + H_2 \times M_2 + H_3 \times M_3}{M_1 + M_2 + M_3}$$

where:

**H<sub>1</sub>, H<sub>2</sub>, H<sub>3</sub>** - Hours of coverage for segments 1, 2, and 3.

**M<sub>1</sub>, M<sub>2</sub>, M<sub>3</sub>** - Miles of segments 1, 2, and 3.

#### 1.2.5.3 Average patrol speed (D).

The average speed (MPH) of units while on "uncommitted patrol" on category 1 roadways (i.e., it does not include the average speed during travel to an accident or other CFS or travel while performing administrative or self-initiated activities or while on uncommitted patrol on non-category 1 roadways). This value can be determined by dividing the miles driven while on uncommitted patrol (on category 1 roadways) per shift by the time spent on uncommitted patrol (on category 1 roadways) during the shift. The

uncommitted patrol time spent on a particular roadway type equals the shift length minus time spent on accidents, other CFS, self-initiated, administrative activities, and uncommitted time spent on other roadway types. Note that uncommitted patrol time includes time spent on both stationary and moving patrol even when speeds are reduced because of traffic volumes or control devices.

1.2.5.4 Patrol interval performance objective (P).

The patrol interval indicates the frequency with which a trooper will pass a given point on a category 1 roadway. Measured in hours, it is the average time a stranded motorist would have to wait for a trooper to come by on uncommitted patrol. As the patrol interval objective is lowered, the number of troopers required increases. As examples, consider the table below (based on 8-hour shifts):

<u>Patrol Interval (hours)</u>	<u>Patrol Frequency (times past fixed location)</u>
2	4 times per shift
4	2 times per shift
8	once a shift
24	once per day
168	once per week

Note that "patrol interval" and "patrol coverage" are not directly related. Patrol coverage merely indicates responsibility for patrolling a roadway segment. The patrol interval determines the extent or intensity of the coverage.

1.2.6 Patrol operations - roadway category 2

See instructions for steps 1.2.5.1 - 1.2.5.4.

1.2.7 Patrol operations - roadways category 3

See instructions for steps 1.2.5.1 - 1.2.5.4.

1.3 Workload Data for the APA

1.3.1 Total number of days in the sample period (D).

Collect accident and other CFS data for the previous 1, 2, or 3 years.

1.3.2 Total number of accidents during the sample period (D).

Total number of accidents handled or investigated by the agency during the sample period. The number should include accidents in which the agency only provides backup services.

1.3.3 Average service time (hours) per accident (D).

The average time required to handle one accident. The average time can be determined on the basis of a sample of 100 or more accidents. The average service time for an accident includes:

- travel time to the accident,
- on-scene time,
- report writing time,
- follow-up investigation time, and
- time charged by all agency units assigned to the accident.

Note that the average service time for accidents does not include dispatching time.

1.3.4 Total number of other CFS during the sample period (D).

Total number of other CFS handled by the agency during the sample period. The number should include CFS for which the agency only provides backup support.

1.3.5 Average service time(hours) per other CFS (D).

The average time required to process one CFS. The average time can be determined on the basis of a sample of 100 or more other CFS. The average service time for a CFS includes:

- travel time to the CFS,

- on-scene time,
- report writing time,
- follow-up investigation time, and
- time charged by all agency units assigned to the CFS.

Note that the average service time for other CFS does not include dispatching time.

#### 1.4 Roadway Data for the APA

For steps 1.4.1 - 1.4.3, enter the number of miles in the patrol area for category 1, 2, and 3 type roadways based on the roadway category definitions determined by the agency.

The total miles determined should be based on roadways in the jurisdiction of the agency that are routinely patrolled by agency personnel. Roadway miles within a municipality that are considered within the jurisdiction of the state agency, but are not usually patrolled by troopers would not be included.

Note that if visibility or access to opposing lanes is limited (e.g., on some interstate roadways and urban expressways), each direction of travel can be considered as a separate roadway in determining total length.



- 1.2.3 Average number of troopers to be supervised by each field supervisor . . . . . +))))))))) , \* \* .))))))))) - (1.2.3)
  
- 1.2.4 Percentage of field supervisor on-duty time spent on uncommitted patrol, reactive, and self-initiated activities . . . . . +))))))))) , \* \* .))))))))) - (1.2.4)
  
- 1.2.5 Patrol operations - roadway category 1
  - 1.2.5.1 Category 1 roadway type . . . . . +))))))))) , \* \* .))))))))) - (1.2.5.1)
  
  - 1.2.5.2 Coverage per week (hours), (maximum value = 168) . . . . . +))))))))) , \* \* .))))))))) - (1.2.5.2)
  
  - 1.2.5.3 Average uncommitted patrol speed (MPH) . . . . . +))))))))) , \* \* .))))))))) - (1.2.5.3)
  
  - 1.2.5.4 Patrol interval performance objective (hours) . . . . . +))))))))) , \* \* .))))))))) - (1.2.5.4)





activities are counted more than once. (See the instructions for operations data in Worksheet 1 above and Section 3 in the Guide.)

Instruction for Individual Steps

- 2.1 User specifies average number of minutes per hour per trooper spent on administrative time (P).
- 2.2 Determine  $m_a$  based on the historical experience of the agency within the APA (D).
  - 2.2.1 Select a sample period (e.g., one year) and collect data that indicates the total amount of time (hours) spent by the patrol force on administrative activities during the sample period within the APA.
  - 2.2.2 Determine the total number of on-duty hours on patrol provided in the APA during the sample period used for Step 2.2.1.

2.3 Administrative Time

User selects a value for  $m_a$  based on either section 2.1 or 2.2.

Note that the value selected for  $m_a$  (Step 2.3) must satisfy the following condition:

$$0 \leq m_a < 60.$$

This condition requires that the total administrative time per hour for administrative activities must be greater than or equal to zero minutes and less than 60 minutes. In practice, administrative time per trooper is usually less than 20 minutes per hour.





Instructions for Worksheet 3: Reactive Time

Worksheet 3 is used to determine the average number of on-duty troopers ( $N_r$ ) that are needed each day to handle accidents and other CFS within an APA. The average number of on-duty troopers required per day is determined with the formula:

$$N_r = \frac{\text{Average Total Obligated Time (hours) Per Day For Accidents and Other CFS}}{\text{Shift Length (hours)}}$$

Derivation of this formula is presented in Section D.1 in Appendix D in the Guide.

Sections 3.1 and 3.2 are used to determine the average obligated time per day for accidents and other CFS respectively. If desired, the "other CFS" category can be divided into subcategories (e.g., other agency assists, criminal calls, etc.) for informational purposes. The total average obligated time per day is obtained in Step 3.3.1, and the number of on-duty troopers is calculated in Step 3.3.3.

Agencies that are using computer-aided dispatching (CAD) systems may be able to obtain the total obligated time data required for steps 3.1.3 and 3.2.3 directly. Agencies that use this approach should insure that the total time reported by the CAD system includes all of the elements of obligated time; i.e.,

- o travel time to the scene,
- o on-scene time,
- o report writing time,
- o follow-up investigation time, and
- o time consumed by all units involved with the incident.





Instructions for Worksheet 4: Proactive Time - Self-initiated

Worksheet 4 is used to determine the average number of minutes per hour ( $m_s$ ) each trooper spends on self-initiated activities within the APA. Three alternative procedures are available to determine  $m_s$ . The user can either:

- (1) select the value directly based on agency policy (Section 4.1),
- (2) determine the value indirectly by specifying a number of self-initiated contacts per shift per trooper, the shift length of the agency, and the average time per contact (based on agency experience within the APA) (Section 4.2), or
- (3) determine the value based on agency workload experience within the APA (Section 4.3).

Instructions for Individual Steps

- 4.1 User selects the average number of minutes per hour per trooper to be spent on self-initiated activities within the APA (P).
- 4.2 User selects  $m_s$  based on a performance objective for the average number of self-initiated contacts (i.e., warnings, citations, assists, etc.) per shift, the agency shift length, and the average time per contact within the APA (P) (D).
  - 4.2.1 Collect data to determine the total number of self-initiated contacts within the APA during a specified sample period (e.g., one year).
  - 4.2.2 Determine the total time (hours) spent on self-initiated activities by the patrol force within the APA during the same sample period used for Step 4.2.1.
- 4.3 Determine  $m_s$  based on agency experience within the APA (D).
  - 4.3.1 Determine the total time (hours) spent on self-initiated activities within the APA during a sample period (e.g., one year). Note: the total hours indicate the time actually spent handling self-initiated activities; i.e., issuing violations, assisting disabled motorists, etc. It does not include the time spent in looking for these activities.
  - 4.3.2 Determine the total on-duty hours on patrol within the APA during the sample period used for Step 4.3.1.
- 4.4 Proactive Time (Self-initiated)

User selects a value for  $m_s$  based on either section 4.1, 4.2, or 4.3.

Note that the values selected for  $m_a$  (Section 2.3) and  $m_s$  (Section 4.4) must satisfy the following conditions:

$$0 \leq m_a < 60,$$

$$0 \leq m_s < 60, \text{ and}$$

$$0 \leq m_a + m_s < 60.$$

These conditions require that the total time per hour for administrative activities, self-initiated activities, and for administrative and self-initiated activities combined must be greater than or equal to zero minutes and must be less than 60 minutes. In practice, self-initiated time per hour is usually less than 15 minutes.

The PAM field test results suggest that the combined times for administrative and self-initiated activities (i.e.,  $m_a + m_s$ ) for most agencies falls in the range: 15 - 30 minutes per hour; i.e.,

$$15 \leq m_a + m_s \leq 30.$$

It should be noted that the general structure of the PAM model is predicated on the assumption that administrative and self-initiated activities together do not consume a majority of available patrol time (i.e., that  $m_a + m_s \leq 30$  minutes). The use of a combined time for administrative and self-initiated activities that is greater than 30 minutes is not recommended.



- 4.2.2 Total time (hours) spent on self-initiated contacts within the APA by all troopers on patrol during the sample period . . . . . +))))))))) , \* \* .))))))))) - (4.2.2)
- 4.2.3 Average time (hours) per self-initiated contact within the APA during the sample period, divide: (4.2.2) ÷ (4.2.1) . . . . . +))))))))) , \* \* .))))))))) - (4.2.3)
- 4.2.4 Select number of self-initiated contacts per shift per trooper performance objective . . . . . +))))))))) , \* \* .))))))))) - (4.2.4)
- 4.2.5 Shift length (hours), use (1.2.1) . . . . . +))))))))) , \* \* .))))))))) - (4.2.5)
- 4.2.6 Number of self-initiated contacts per hour per trooper, divide: (4.2.4) ÷ (4.2.5) . . . . . +))))))))) , \* \* .))))))))) - (4.2.6)
- 4.2.7 Self-initiated performance objective for the APA in minutes per hour per trooper, multiply: 60 x (4.2.3) x (4.2.6) . . . . . +))))))))) , \* \* .))))))))) - (4.2.7)

Continue with Section 4.4

)))))))))

OR

)))))))))



user for each roadway type within the APA. The formula for the number of troopers (used in steps 5.1.2.6, 5.1.3.6, and 5.1.4.6) is based on:

- o the number of roadway miles,
- o the hours of patrol coverage per week,
- o the average patrol speed (MPH),
- o the shift length (hours), and
- o the patrol interval (hours) set by agency policy.

The total number of troopers required for uncommitted patrol equals the sum of the number of troopers needed for each roadway type (Step 5.1.5). The derivation of the formula used in steps 5.1.2.6, 5.1.3.6, and 5.1.4.6 is presented in Section D.2 in Appendix D in the Guide.

The number of troopers required for rapid response is determined using either section 5.2 or 5.3. Section 5.2 determines the number of troopers that must be available during the hours of coverage to insure that at least one trooper will be available in the APA for immediate dispatch or action for a user-specified percentage of all accidents, CFS, and self-initiated activities. The number of required troopers is based on the number of troopers required for reactive activities, the immediate response percent set by the agency, the hours of patrol coverage per week, and the values determined for  $m_a$  and  $m_s$  in worksheets 2 and 4.

Two procedures are available for determining the number of troopers required for immediate availability. A simplified procedure based on Table 3-1 is presented in Section 5.2. If the simplifying assumptions used in Section 5.2 are not valid, a supplemental worksheet in Appendix A can be used. For either procedure, the final number of uncommitted patrol officers required is obtained from a table (either Table 3-1 for Section 5.2 or one of several tables in Appendix A) based on a queuing theory model that assumes that accidents, other CFS, and self-initiated activities occur randomly and that service times are distributed exponentially. The derivations of the formulas and procedures used in Section 5.2 and in the Supplemental Worksheet are presented in Section D.3 in Appendix D in the Guide.

Section 5.3 determines the number of troopers that must be available in the APA to provide a specified average travel time. Steps (5.3.1) through (5.3.6) are used for patrol over a designated geographic area. A supplemental worksheet in Appendix B can be used when patrol is provided on a designated roadway seg-

ment (i.e., a line patrol). The value obtained from the supplemental worksheet is entered in Step (5.3.7) and the total number of troopers required to meet the travel time requirement is determined in Step (5.3.8).

The formula for the number of troopers required for area patrol (Step 5.3.6) is based on:

- o shift length (hours),
- o area (square miles) of the APA,
- o patrol coverage per week (hours),
- o average response speed (MPH), and
- o average travel time specified by the agency.

The derivation of the formula for travel time for area patrol is presented in Section D.4 in Appendix D in the Guide.

The formula for the number of troopers required for line patrol (supplemental worksheet in Appendix B) is based on:

- o shift length (hours),
- o patrol coverage per week (hours),
- o number of roadway miles,
- o coverage per week (hours),
- o average response speed (MPH), and
- o average travel time specified by the agency.

The derivation of the formula for travel time for line patrol is presented in Section D.5 in Appendix D in the Guide.

Whether response time is based on area or line patrol or both, the average response speed that is used should be equal to or greater than the average patrol speed used in Section 5.1.

The average number of troopers per day for uncommitted patrol ( $N_p$ ) is determined by calculating the number of troopers required for visibility (Step 5.1.5) and the number of troopers required for timely response (Step 5.4) and using the larger of the two values (Step 5.5).

Instructions for Individual Steps

5.1 Uncommitted Patrol Visibility

5.1.2.4 The average patrol speed (MPH) is defined as the average speed while on "uncommitted patrol" on category 1 roadways only. Uncommitted patrol is defined as the total shift time minus time spent on reactive (i.e., accidents and CFS), self-initiated, and administrative activities, and uncommitted time on non-category 1 roadways. Some agencies make a distinction between "moving" and "stationary" patrol. The PAM model does not make this distinction and the average patrol speed used in the PAM model should be based on both moving and stationary patrol time while on category 1 roadways. If the average patrol speed is known for moving patrol time only, it is possible to estimate the overall patrol speed with the formula given below.

$$\begin{array}{rcl} \text{Average} & & \text{Average} & & \text{Fraction of} \\ \text{Patrol Speed} & = & \text{Patrol Speed} & \times & \text{Time on Moving} \\ \text{(MPH)} & & \text{(moving) (MPH)} & & \text{Patrol} \end{array}$$

As an example, if the average speed during moving patrol is estimated to be 40 MPH and moving patrol time represents approximately 50% of total uncommitted patrol time, then the average patrol speed that should be used in the PAM model is 20 MPH (i.e.,  $20 = 40 \times .50$ ). The fraction of time on moving patrol (a number between 0 and 1) is obtained by dividing the percent of time by 100. Notice that if all uncommitted patrol time is spent on moving patrol, the average speed patrol for the PAM model equals the average speed for moving patrol.

5.1.3.4 Average patrol speed on uncommitted time on category 2 roadways. See discussion above for Step 5.1.2.3.

5.1.4.4 Average patrol speed on uncommitted time on category 3 roadways. See discussion above for Step 5.1.2.3.

5.2 Uncommitted Patrol Availability - Immediate Response

Determination of the number of troopers needed for immediate response in Section 5.2 is based on three simplifying assumptions:

1. staffing is uniform over all shifts,
2. the values for  $m_a$  (Step 2.3) and  $m_s$  (Step 4.4) are approximately 15 and 9 minutes per hour per trooper respectively, and
3. the same user-specified immediate response performance objective is used for each shift.

If any of these assumptions is not valid, the user should use the supplemental worksheet in Appendix A to determine the number of troopers needed to satisfy the immediate response performance objective. As a rule of thumb, shift staffing can be considered uniform if the proportion of staff on each shift is within 10% of perfect uniform staffing for each shift. The table below indicates the range of staffing for operations with 2, 3, and 4 shifts.

<u>Number of Shifts</u>	----- Uniform Staffing ----- Percent of Staffing on Each Shift	
	<u>Perfect</u>	<u>Range</u>
2	50.0	45.0 - 55.0
3	33.3	30.0 - 36.7
4	25.0	22.5 - 27.5

5.2.6 Specify the percentage of calls for which at least one trooper will be available for immediate dispatch (P). Select a percentage value that corresponds to one of the columns in Table 3-1. The lowest value is 50% and the highest is 99%.

5.2.7 Determine the number of troopers needed with Table 3-1.

Using Table 3-1:

- o Examine the left-hand column of the table and select the row that is closest to the average daily number of troopers per shift (Step 5.2.5) that are needed to handle the obligated time workload ( $N_r$ ).
- o Read across the row until the percentage at the top of the column equals or exceeds the agency performance objective percentage (Step 5.2.6).
- o The table entry indicates the average number of troopers that are needed on each shift to meet the agency specified percentage. Enter the table value in (5.2.7).

### 5.3 Uncommitted Patrol Availability - Travel Time for Area Patrol and/or Line Patrol

This section is used to determine the average number of troopers required for uncommitted patrol within the APA during the hours of coverage to provide a user-specified average travel time response to CFS for area and/or line patrols. Steps 5.3.1 - 5.3.6 are used for area patrol. Step 5.3.7 is used to record the number of troopers required for line patrol obtained from the supplemental worksheet in Appendix B.

#### 5.3.4 Average response speed (MPH) (D).

The average speed of a patrol unit while responding to a CFS. The average speed is usually lower than anticipated due to factors that may delay or impede a responding unit (e.g., heavy traffic, cornering, etc.)

#### 5.3.5 Average travel time performance objective (minutes) (P).

The user-specified average travel time performance objective for patrol unit response to accidents and other CFS within the APA. It is important to note that this procedure is based on the average travel time. The number of troopers determined in Step (5.3.6) will provide a level of availability that will produce travel times that collectively will equal the travel time objective value. For individual responses, however, some travel times will be lower than the objective value and some will be higher. The number of troopers obtained in Step (5.3.6) does not guarantee that the travel time to every incident will be less than the agency-specified objective value.

5.3.7 Number of troopers required for line patrol.

See discussion in Appendix B.



(5.1.2.5)

5.1.2.6 Number of troopers required per day to meet the patrol interval performance objective for category 1 roadways in the APA, use the formula below . . .  
 +))))))))) ,  
 \* \*  
 .))))) -  
 (5.1.2.6)

		Roadway Miles (5.1.2.2)	x	Hours of Coverage Per Week (5.1.2.3)	
Number of Troopers (5.1.2.6)	=	)))))))))		)))))))))	)))))))))
		Average Patrol Speed (5.1.2.4)	x	Shift Length (5.1.1)	x
		7		Perf. Obj. Patrol Interval (5.1.2.5)	)))))))))

5.1.3 Number of troopers needed per day for uncommitted patrol on category 2 roadways in the APA

5.1.3.1 Category 2 roadway type, use (1.2.6.1) . . .  
 +))))))))) ,  
 \* \*  
 .))))) -  
 (5.1.3.1)

5.1.3.2 Miles of roadway, use (1.4.2) . . . . .  
 +))))))))) ,  
 \* \*  
 .))))) -  
 (5.1.3.2)

5.1.3.3 Hours of coverage per week, use (1.2.6.2) . . . . .  
 +))))))))) ,  
 \* \*  
 .))))) -  
 (5.1.3.3)

5.1.3.4 Average patrol speed (MPH), use (1.2.6.3) . . . . .  
 +))))))))) ,  
 \* \*  
 .))))) -  
 (5.1.3.4)

5.1.3.5 Performance objective patrol interval (hours), use (1.2.6.4) . . . . .  
 +))))))))) ,  
 \* \*  
 .))))) -  
 (5.1.3.5)

5.1.3.6 Number of troopers required per day to meet the patrol interval performance objective for category 2 roadways in the APA, use the formula below . . . (5.1.3.6)

$$\begin{array}{r}
 \text{Number of Troopers (5.1.3.6)} \\
 = \\
 \text{Roadway Miles (5.1.3.2)} \times \text{Hours of Coverage Per Week (5.1.3.3)} \\
 \times \text{Average Patrol Speed (5.1.3.4)} \times \text{Shift Length (5.1.1)} \times \text{Perf. Obj. Patrol Interval (5.1.3.5)}
 \end{array}$$


---

5.1.4 Number of troopers needed per day for uncommitted patrol on category 3 roadways in the APA

5.1.4.1 Category 3 roadway type, use (1.2.7.1) . . . (5.1.4.1)

5.1.4.2 Miles of roadway, use (1.4.3) . . . . . (5.1.4.2)

5.1.4.3 Hours of coverage per week, use (1.2.7.2) . . . . . (5.1.4.3)

5.1.4.4 Average patrol speed (MPH), use (1.2.7.3) . . . . . (5.1.4.4)

5.1.4.5 Performance objective patrol interval (hours), use (1.2.7.4) . . . . . (5.1.4.5)

5.1.4.6 Number of troopers required per day to meet the patrol



(5.2.3)

$$\begin{aligned} & \text{Effective} & & \text{Coverage Per} \\ & \text{Number of} & & \text{Week (hours)} \\ & \text{Shifts Per} & = & \text{(5.2.2)} \\ & \text{Day (5.2.3)} & & \text{)))))))))) \\ & & & \text{Shift Length} \\ & & & \text{(hours)} \\ & & 7 \times & \text{(5.2.1)} \end{aligned}$$

$$\begin{aligned} 5.2.4 \text{ Average daily number of} & & & \text{+)))))))))) \\ & \text{on-duty troopers for} & & * \\ & \text{reactive time, use (3.3.3) . . . .} & & * (\mathbf{N_r}) \\ & & & \text{)))))))))) - \\ & & & \text{(5.2.4)} \end{aligned}$$

$$\begin{aligned} 5.2.5 \text{ Average daily number of} & & & \text{+)))))))))) \\ & \text{on-duty troopers per shift } (\mathbf{N_{rs}}), & & * \\ & \text{divide: (5.2.4) } \div \text{ (5.2.3) . . . .} & & * (\mathbf{N_{rs}}) \\ & & & \text{)))))))))) - \\ & & & \text{(5.2.5)} \end{aligned}$$

$$\begin{aligned} 5.2.6 \text{ Performance objective,} & & & \\ & \text{percentage of accidents, CFS,} & & \\ & \text{and self-initiated activities,} & & \text{+)))))))))) \\ & \text{immediate response (a number} & & * \\ & \text{between 50 and 99) . . . . .} & & * \mathbf{PIR\%} \\ & & & \text{)))))))))) - \\ & & & \text{(5.2.6)} \end{aligned}$$

$$\begin{aligned} 5.2.7 \text{ Number of troopers required} & & & \text{+)))))))))) \\ & \text{per shift, use (5.2.5),} & & * \\ & \text{(5.2.6), and Table 3-1 . . . . .} & & * \\ & & & \text{)))))))))) - \\ & & & \text{(5.2.7)} \end{aligned}$$

$$\begin{aligned} 5.2.8 \text{ Total number of uncommitted patrol} & & & \\ & \text{troopers required per day within the} & & \\ & \text{APA to provide immediate response to} & & \\ & \text{the performance objective percentage} & & \\ & \text{of accidents and CFS, either} & & \text{+)))))))))) \\ & \text{multiply: (5.2.3) } \times \text{ (5.2.7) or} & & * \\ & \text{enter value from Step (A.7) . . . .} & & * \\ & & & \text{)))))))))) - \\ & & & \text{(5.2.8)} \end{aligned}$$



Continue with Section 5.4.

))

OR

))

**5.3 Uncommitted Patrol Availability - Travel Time  
for Area Patrol (Steps 5.3.1 - 5.3.6) and/or  
Line Patrol (Step 5.3.7)**

5.3.1	Shift length (hours), use (1.2.1) . . . . .	+))))))))) * * .))))))))) - (5.3.1)
5.3.2	Coverage per week (hours) (maximum value = 168) . . . . .	+))))))))) * * .))))))))) - (5.3.2)
5.3.3	Area (square miles) of the APA . . . . .	+))))))))) * * .))))))))) - (5.3.3)
5.3.4	Average response speed (MPH) (equal to or greater than average patrol speed) . . . . .	+))))))))) * * .))))))))) - (5.3.4)
5.3.5	Average travel time performance objective (minutes) . . . . .	+))))))))) * * .))))))))) - (5.3.5)
5.3.6	Number of troopers required within the APA to meet the average travel time performance objective for area patrol	
5.3.6.1	Calculate <b>K</b> based on formula below . . . . .	+))))))))) * * .))))))))) - (5.3.6.1) ( <b>K</b> )





Sections 6.2 and 6.3 are used to add troopers to account for the use of two-trooper patrol units and the presence of minimum staffing requirements set by the agency. The derivation of the formula for adjusting the number of on-duty troopers for two-trooper units is presented in Section D.7 in Appendix D in the Guide.

Instructions for Individual Steps

6.1 Number of On-Duty Troopers per Day - All One-Trooper Patrols (C)

With the completion of Step 6.1.5, it is possible to determine how much time each trooper, on the average, will spend on each of the four work categories: reactive, self-initiated, uncommitted patrol, and administrative. The four times are given by:

$$\begin{aligned}
 \text{Administrative Time (min/hr)} &= m_a \text{ (Step 2.3),} \\
 \text{Self-Initiated Time (min/hr)} &= m_s \text{ (Step 4.4),} \\
 \text{Reactive Activities Time (} m_r \text{) (min/hr)} &= \frac{N_r \text{ (3.3.3)} \times 60}{N_o \text{ (6.1.5)}}, \text{ and} \\
 \text{Uncommitted Patrol Time (min/hr)} &= 60 - m_a - m_s - m_r .
 \end{aligned}$$

The four times will sum to 60 minutes. The time (in hours) spent on each activity for an entire shift can be determined by dividing each time by 60 and multiplying by the shift length (in hours).

6.2 Adjustment for Two-Trooper Patrol Units (P).

6.2.1 The percentage of time that patrol units are staffed with two troopers. A value of 0 indicates that no patrol units within the APA are staffed with two troopers while a value of 100 indicates that every patrol unit has two troopers.

6.2.3 The adjustment factor is a number between 1 and 2 that is derived from the percentage entered for (6.2.1).

The factor indicates the average number of troopers per unit. A value of 1 indicates an average of one trooper per unit (i.e., no two-trooper units are used). A value of 2 indicates that every unit has two troopers.

### 6.3 Minimum Staffing Level

The minimum number of on-duty troopers that must be available each day in the APA as determined by agency policy.







Instructions for Worksheet 7: Special Assignments and  
Field Supervision

Worksheet 7 is used to determine the impact of special assignment units (e.g., inspections, K9, accident investigation, etc.) on total patrol staffing and the number of field supervisors required in the APA.

The impact of special assignment personnel is based on the number of on-duty troopers required for each type of specialized unit (specified by the agency) and the percentage of patrol work, if any, performed by the specialists. The procedure assumes that the number of troopers on special assignments is permanent (i.e., that they will continue on the assignment for an indefinite period of time). Additional staffing for non-permanent or temporary assignments such as traffic and crowd control at special events (e.g., a county fair) is considered in the derivation of the shift relief factor in Worksheet 8.

The number of field supervisors is based on the span of supervision (i.e., the average number of troopers that report to each field supervisor) set by agency policy and the amount of patrol work done by each field supervisor.

The derivations of the formulas used for steps 7.1.6, 7.2.1.6, 7.2.2.6, 7.2.3.6, 7.2.4, and 7.3.1 are presented in Section D.8 of Appendix D in the Guide.

Instructions for Individual Steps

Since field supervisors, and troopers assigned to special assignments, may spend part of their time performing patrol activities, the addition of field supervisors and special assignment personnel to the patrol force may reduce the number of full-time (i.e., non-supervisory and non-special assignment) troopers that are needed. The number of on-duty troopers determined in sections 7.1 and 7.2 consists of an adjusted number of full-time troopers and the number of troopers used for special assignments.

7.1 Number of full-time, on-duty troopers required per day, adjusted for field supervisors (P,D,C)

The adjusted number of full-time, on-duty troopers ( $N_{ao}$ ) is based on the number of troopers ( $N_o$ ) derived in Step 6.3.2, the average number of troopers supervised by each field supervisor (Step 7.1.1), and the percentage of on-duty time field supervisors spend on patrol activities (i.e., time spent on reactive,

self-initiated, uncommitted patrol, and non-supervisory administrative work) (Step 7.1.2). If field supervisors spend no time on patrol activities, then the adjusted number of full-time, on-duty troopers required is unchanged (i.e.,  $N_{ao} = N_o$ ).

7.2 Number of on-duty troopers required per day, adjusted for special assignment personnel (D,C)

If special assignment personnel are used, Section 7.2 can be used for up to three types of special assignments, and can be easily modified by the user if more than three are needed. The adjustment is based on the adjusted number of full-time, on-duty troopers ( $N_{ao}$ ) derived in Step 7.1.6; the number of on-duty troopers required for special assignments (i.e.,  $N_{s1}$ ,  $N_{s2}$ , and  $N_{s3}$  in steps 7.2.1.1, 7.2.2.1, and 7.2.3.1); and the percentage of time special assignment personnel spent on patrol activities (i.e., time spent on reactive, self-initiated, uncommitted patrol, and patrol-related administrative work) (steps 7.2.1.2, 7.2.2.2, and 7.2.3.2). The final adjusted value for the number of on-duty troopers required per day ( $N_{ot}$ ) is determined in Step 7.2.4 and includes both full-time patrol troopers and troopers who spend all or part of their time on special assignments.

Note that the number of full-time, on-duty troopers per day ( $N_{ft}$ ) is given by:

$$N_{ft} = N_{ot} - N_{s1} - N_{s2} - N_{s3}$$

(7.2.4)    (7.2.1.1)    (7.2.2.1)    (7.2.3.1)

7.3 Total number of on-duty field supervisors ( $N_{os}$ ) required per day for the adjusted number of on-duty troopers ( $N_{ot}$ ) (C)

The number of on-duty field supervisors ( $N_{os}$ ) is based on the adjusted number of on-duty troopers ( $N_{ot}$ ) from Step 7.2.4 and the number of troopers assigned to each field supervisor (Step 7.1.1). The value determined for  $N_{os}$  in Step 7.3.1 includes supervisors for both full-time patrol troopers and troopers assigned to special units.







(7.2.1.1)

7.2.2.2 Average number of  
on-duty troopers per  
day on specialized  
assignment 2 . . . . . +))))))))) ,  
\* \* (N<sub>s2</sub>)  
.))))))))) -  
(7.2.2.2)

7.2.2.3 Percentage of on-duty  
time spent on patrol  
activities by troopers  
assigned to special  
assignment 2 (a number  
between 0 and 100) . . . . +))))))))) ,  
\* \*  
.))))))))) -  
(7.2.2.3)







Instructions for Worksheet 8: Total Staff Requirements

Worksheet 8 is used to determine the total staff needed to support the on-duty trooper and field supervisor requirements determined in worksheets 6 and 7. The total staff requirements for the APA are derived using the following procedure:

- o Sections 8.1, 8.2, and 8.3 are used to determine the total number of troopers and field supervisors, both on and off-duty, that are needed.
- o Section 8.4 is used to indicate the total number of staff and command personnel that are required.
- o Section 8.5 is used to collect the results into a final tabulation of the total staff requirements for the APA.

The total number of troopers and field supervisors required is determined based on the shift relief factor for the APA. The shift relief factor is defined as the average number of persons required to staff one shift position per day, 365 days a year. The shift relief factor for an APA is calculated with the following formula:

$$\begin{array}{l}
 \text{Shift} \\
 \text{Relief} \\
 \text{Factor}
 \end{array}
 =
 \frac{\begin{array}{l}
 \text{Total Number of Hours To Cover One Shift} \\
 \text{Position Per Day, 365 Days Per Year}
 \end{array}}{\begin{array}{l}
 \text{Average Number of Actual On-Duty Hours} \\
 \text{On Patrol Per Person Per Year}
 \end{array}}$$

The average number of actual on-duty hours on patrol per person per year is determined by the average work week, the shift length, the benefit time policies (i.e., vacation time, holiday leave, sick leave, etc.) of the agency, and the extent to which troopers are used for non-patrol activities. For agencies with eight-hour shifts, shift relief factors usually fall between 1.60 and 1.90. Derivation of the shift relief factor formula is presented in Section D.9 in Appendix D in the Guide.

To indicate the number of staff and command personnel, the user must specify the number directly in Section 8.4.

Instructions for Individual Steps

## 8.2 Shift Relief Factor

### 8.2.7 Average number of on-duty hours on patrol per officer per year

This value is obtained by taking the total hours that an officer is paid per year (Step 8.2.4) and subtracting the total hours for benefit time (Step 8.2.5) and temporary assignments (Step 8.2.6).

## 8.4 The Number of Staff and Command Personnel - Agency Policy (P).

This category should include all command personnel (e.g., lieutenants, captains, majors, etc.) and other staff personnel (i.e., administrative, technical, etc.) that are needed for the supervision and support of the patrol force within the APA. The specific kinds of personnel included in this category will vary from agency to agency.







APPENDIX A: Supplemental Worksheet for Worksheet 5, Section 5.2

Instructions for Supplemental Worksheet:  
Uncommitted Patrol Availability - Immediate Response

The supplemental worksheet for Section 5.2 can be used to determine the number of patrol troopers ( $N_p$ ) that will be required to insure that the probability that at least one trooper will be available for immediate response to an accident, CFS, or self-initiated activity meets or exceeds the user-specified performance requirement.

The number of patrol troopers ( $N_p$ ) is based on the number of on-duty troopers required for reactive activities ( $N_r$ ) determined in Worksheet 3, the average number of administrative minutes per hour per trooper ( $m_a$ ) determined in Worksheet 2, the average number of minutes per hour per trooper spent on self-initiated activities ( $m_s$ ) determined in Worksheet 4, and the estimated staffing distribution by time of day (i.e., by shift). The number of patrol troopers is determined using a queuing model that assumes randomly occurring accidents, CFS, and self-initiated activities with exponentially-distributed service times.

The procedure for determining  $N_p$  in Section 5.2 in Worksheet 5 relies on the following assumptions:

- o the agency has uniform staffing on all shifts,
- o the values for  $m_a$  and  $m_s$  are approximately equal to 15 and 9 minutes per hour per trooper respectively, and
- o the same user-specified immediate response performance requirement applies to each shift.

These assumptions, valid for a wide range of agencies and operations, simplify the determination of  $N_p$  (Table 3-1 can be used to determine  $N_p$  for every shift).

If any of the assumptions cited above are not valid or applicable, the supplement worksheet presented below can be used in place of Section 5.2. The supplement worksheet determines the

number of patrol troopers per day by estimating the number required for each shift and adding the results together. The number of patrol troopers required for each shift ( $N_{p1}$ ,  $N_{p2}$ , and  $N_{p3}$ ) is determined with a table look-up based on the estimated number of on-duty troopers required for reactive activities on each shift ( $N_{r1}$ ,  $N_{r2}$ , and  $N_{r3}$ ). The appropriate table to be used is based on the values for  $m_a$  and  $m_s$  determined in worksheets 2 and 4 respectively.

The derivations of the formulas and procedures used in Section 5.2 and in the supplemental worksheet are presented in Section D.3 in Appendix D in the Guide.

### Instructions for Individual Steps

#### A.2 Staffing Level By Shift

The values entered for (A.2.1), (A.2.2), and (A.2.3) represent the user's estimate of the percentage of staff that will be on duty on each shift for the APA. The sum of the percents over all shifts must equal 100. (Section 5.2 assumes the same percent for each shift.)

#### A.5 Determine Appropriate Table

A.5.1  $K_s$  values are always positive and usually fall in the range of 0.15 to 0.35. Higher  $K_s$  values produce larger  $N_p$  values.

#### A.6 Number of Patrol Troopers Required for Each Shift

##### A.6.1 Number of Patrol Troopers Required for Shift 1

A.6.1.1 The supplemental worksheet permits the user to select, if desired, a different immediate response performance objective percentage for each shift. (Section 5.2 uses the same performance objective value for all shifts.)

A.6.1.2 The expected number of daily on-duty troopers for reactive activities for shift 1 ( $N_{r1}$ ) is based on the user-specified staffing percent for shift 1 recorded in (A.2.1).

A.6.1.3 The table look-up process consists of the following steps:

- o Locate the table identified in Step A.5.2.
- o Examine the left-hand column of the table and select the row that is closest to the average daily number of reactive troopers for shift 1 (A.6.1.2).
- o Read across the row until the percentage at the top of the column equals or exceeds the performance objective percent for shift 1 (A.6.1.1).
- o The table entry indicates the average number of patrol troopers that are needed on shift 1 to meet the performance objective. Enter the table value in (A.6.1.3).

A.6.2 Number of Patrol Troopers Required for Shift 2

Read A.6.1.1, A.6.1.2, and A.6.1.3 above.

A.6.3 Number of Patrol Troopers Required for Shift 3

Read A.6.1.1, A.6.1.2, and A.6.1.3 above.

SUPPLEMENTAL WORKSHEET: Uncommitted Patrol Availability - Immediate Response

Objective: Determine the number of troopers required within the APA to provide an immediate response to a user-specified percent of all accidents, CFS, and self-initiated activities.

Method: A queuing model formulation for each shift based on randomly-occurring accidents, CFS, and self-initiated activities with exponentially-distributed service times. Input data includes the number of on-duty troopers required per day for reactive activities, the estimated staffing by shift, the average number of minutes per hour per trooper spent on administrative and self-initiated activities, and user-specified performance objectives for each shift.





+))))))))))))))))))))))))))))))))))))))		
*		Use *
* If $K_s$ (A.5.1)	Table	*
* is in the range	(A.5.2)	*
/)))))))))))))))))))))))))))))))))))))) 1		
* 0 - .099	A-1	*
* .1 - .199	A-2	*
* .2 - .249	3-1	*
* .25 - .299	A-3	*
* .3 - .399	A-4	*
* .4 - .499	A-5	*
* .5 - .599	A-6	*
* .6 - .699	A-7	*
* .7 - .799	A-8	*
* .8 - .899	A-9	*
* .9 or larger	A-10	*
.)))))))))))))))))))))))))))))))))))))) -		

A.6 Number of patrol troopers required for each shift

A.6.1 Number of patrol troopers required for shift 1

- A.6.1.1 Performance objective, percent of accidents and CFS, immediate response (a number between 50 and and 99) . . . . . +)))))))))))))) , \* \* .)))))))))))))) - (A.6.1.1)
  
- A.6.1.2 Expected number of daily on-duty troopers for reactive activities on shift 1, use formula below . . . . . +)))))))))))))) , \* \*  $(N_{r1})$  .)))))))))))))) - (A.6.1.2)

Expected Number of On-Duty Troopers Per Day for Reactive Activities on Shift 1, (N<sub>r1</sub>) (A.6.1.2) =  $\frac{\text{Percent of Staff on Shift 1 (A.2.1)} \times \text{Total Number of On-Duty Troopers Per Day (N}_r \text{ (A.1))}}{100}$

A.6.1.3 Number of troopers required for shift 1, use (A.6.1.1), (A.6.1.2), and the table specified in (A.5.2) . . . . . +))))) \* (N<sub>p1</sub>) (A.6.1.3)



A.6.2 Number of patrol troopers required for shift 2

A.6.2.1 Performance objective, percent of accidents and CFS, immediate response (a number between 50 and and 99) . . . . . +))))) \* (A.6.2.1)

A.6.2.2 Expected number of daily on-duty troopers for reactive activities on shift 2, use formula below . . . . . +))))) \* (N<sub>r2</sub>) (A.6.2.2)

Expected Number of On-Duty Troopers Per Per Day for Reactive Activities on Shift 2, ( $N_{r2}$ ) (A.6.2.2)	=	Percent of Staff on Shift 2 (A.2.2)	x	Total Number of On-Duty Troopers Per Day ( $N_r$ ) (A.1)	)))))))
			100		

A.6.2.3 Number of troopers required for shift 2, use (A.6.2.1), (A.6.2.2), and the table specified in (A.5.2) . . . . . +))))) , \* \* ( $N_{p2}$ ) .))))) - (A.6.2.3)

-----

A.6.3 Number of patrol troopers required for shift 3

A.6.3.1 Performance objective, percent of accidents and CFS, immediate response (a number between 50 and and 99) . . . . . +))))) , \* \* .))))) - (A.6.3.1)

A.6.3.2 Expected number of daily on-duty troopers for reactive activities on shift 3, use formula below . . . . . +))))) , \* \* ( $N_{r3}$ ) .))))) - (A.6.3.2)

Expected Number of On-Duty Troopers Per Per Day for Reactive Activities on Shift 3, ( $N_{r3}$ ) (A.6.3.2)	=	Percent of Staff on Shift 3 (A.2.3)	x	Total Number of On-Duty Troopers Per Day ( $N_r$ ) (A.1)	)))))))
			100		

A.6.3.3 Number of troopers required for shift 3, use (A.6.3.1), (A.6.3.2), and the table specified in (A.5.2) . . . . . +))))) , \* \* ( $N_{p3}$ ) .))))) -



APPENDIX B: Supplemental Worksheet for Worksheet 5, Step 5.3.7

Instructions for Supplemental Worksheet:  
Uncommitted Patrol Availability - Line Patrol

The supplemental worksheet for Step 5.3.7 is used to determine the number of patrol troopers in the APA during the hours of coverage for line patrol (i.e., uncommitted patrol activities restricted to a roadway segment.) The criterion for determining how many troopers are needed is the average travel time to reactive activities.

This step should only be used when some troopers are assigned to specific roadway segments with no responsibilities other than police services on the roadway. If line patrols are used, the number of troopers required Step (5.3.7) is added to the number of troopers required for area patrol Step (5.3.6) to obtain the total number of troopers to meet the user-specified average travel time performance objective.

The formula for the number of troopers required for line patrol (Step B.6) is based on the:

- o shift length (hours),
- o patrol coverage per week (hours),
- o number of roadway miles,
- o coverage per week (hours),
- o average response speed (MPH), and
- o average travel time specified by the agency.

The derivation of the formula for travel time for line patrol is presented in Section D.5 in Appendix D in the Guide.

Instructions for Individual Steps

## B.3 Roadway Miles to be Patrolled (Miles) (D)

The total number of highway miles for line patrol depends on the access between opposite direction lanes. If complete access is available, the number of highway miles to be patrolled will equal the length of the segment. If, however, no access is available between the opposing direction lanes except at each end of the segment and at a limited number of crossover points, the "effective" number of highway miles to be patrolled will be greater than the length of the segment. The chart below can be used to estimate the "effective" number of miles for line patrol that should be used for Step 5.4.3. To use the chart, find the row that best corresponds to the number and location of crossover points along the highway segment. The entry for Step (5.4.3) is obtained by multiplying the length of the highway segment in miles by the value listed in the righthand column (Adjustment Factor) of the row.

<u>Number of Access Points</u>	<u>Location of Access Points</u>	<u>Adjustment Factor</u>
2	Each end of the segment . . .	3.000
3	Each end of the segment and middle of the segment . . .	2.250
4	Each end of the segment and two crossovers dividing the segment into thirds . .	1.889
5	Each end of the segment and three crossovers dividing the segment into fourths .	1.689
6	Each end of the segment and four crossovers dividing the segment into fifths . .	1.560
Unlimited	Everywhere . . . . .	1.000

## B.4 Average Response Speed (MPH) (D)

The average speed of a patrol unit while responding to a CFS. The average speed is usually lower than anticipated due to factors that may delay or impede a responding unit (e.g., heavy traffic, cornering, etc.).

## B.5 Average Travel Time Performance Objective (Minutes) (P).

The user-specified average travel time performance objective for patrol unit response to accidents and other CFS within the APA. It is important to note that this procedure is based on the average travel time, not a maximum time. The number of

troopers determined in Step (B.6) will provide a level of trooper availability on the roadway segment that will produce travel times that collectively will equal the travel time performance objective value. For individual responses, however, some travel times will be lower than the objective value and some will be higher. The number of troopers obtained in Step (B.6) does not guarantee that the travel time to every incident will be less than the performance objective value.



